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Functional Recovery of COVID-19 Patients Admitted to a Cardiopulmonary Inpatient Rehabilitation Unit

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Abstract: Introduction: With changes in treatments, precautions, and the virus itself, the continued evaluation of post-COVID-19 patient rehabilitation needs is essential. Methods: Demographics, comorbidities, functional assessments, quality of life, and rehabilitation outcomes for 98 patients admitted to inpatient rehabilitation during New York's most recent major COVID-19 hospitalization surge were analyzed. Patients were contacted at 6 months to evaluate functional improvement, post-COVID-19 symptoms, vaccination status, and quality of life. Results: Inpatient rehabilitation addressed significant limitations in lung capacity, mobility, and self-care. Median mobility scores improved significantly from admission (16) to discharge (34) and follow-up (42). Sixty-six percent of patients reported overall quality of life improvement during their rehabilitation stay; at follow-up, a more modest percentage (35%) reported additional gains. Continued improvement in supplemental oxygen use was observed in 49% of patients who completed the follow-up assessment. Consistent with previous studies on severe disease, post-COVID-19 condition features were exhibited by 86% of patients at follow-up; vaccinated individuals displayed fewer symptoms associated with post-COVID-19 condition than their unvaccinated counterparts. Conclusions: Individuals recovering from severe COVID-19, including previously ventilated patients, made significant functional and quality of life gains during inpatient rehabilitation. While functional independence continued to improve post-discharge, patients exhibited greater improvement from admission to discharge than from discharge to 6-month follow-up. Inpatient rehabilitation represents a crucial component for recovery from severe COVID-19.

Keywords: COVID-19; inpatient rehabilitation; post-COVID-19 condition; cardiopulmonary rehabilitation outcomes

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1. Introduction

The COVID-19 pandemic has led to more than 103 million U.S. cases, with over 6 million hospitalizations and 1.1 million deaths [1]. Most patients infected with COVID-19 exhibit mild to moderate symptoms that do not require hospitalization; patients with severe illness often experience respiratory failure, septic shock, and/or multi-system organ failure, requiring long ICU stays with potential mechanical ventilation [2,3]. Several risk factors reported in patients with severe symptoms include aged ≥65, obesity, heart conditions, chronic lung disease, diabetes, chronic kidney disease, and smoking [4–6].

Following the hospitalization of patients with severe COVID-19, 15–20% require inpatient rehabilitation to facilitate a safe discharge home [7]. Deficits addressed include functional mobility, cognition, cardiovascular status, respiratory function, and neuromuscular conditions [7–10]. Post-acute rehabilitation of COVID-19 patients is largely centered around improving functional capacity and addressing fatigue related to activities of daily living (ADLs) and shortness of breath (SOB) [9,11–15].

Several symptoms may appear or persist months after acute illness, collectively referred to as post-COVID-19 condition [9,16–19]. Patients with post-COVID-19 condition demonstrate dysfunction across multiple systems; frequently reported symptoms include cough, phlegm, lack of taste, lack of smell, fatigue, muscular pain, joint pain, headache, confusion, difficulty concentrating, and diarrhea [20,21]. Most post-COVID-19 condition symptoms persist for 2 to 9 months following infection, affecting patients' ability to function at work and home, and ultimately negatively impacting quality of life [21]. Currently, there is a concerted effort to understand the long-term effects of COVID-19. Patients at risk of post-COVID-19 condition largely overlap with those who have experienced severe disease; thus, there is an enrichment of post-COVID-19 condition in patients requiring inpatient rehabilitation [16].

The characteristics of hospitalized patients and the list of post-COVID-19 condition symptoms have changed over time [22,23]. Vaccine availability, improved treatments and protocols, and the mutating virus itself have led to differences in both underlying patient characteristics as well as the presentation of symptoms across the multiple waves of COVID-19. The purpose of this study was to characterize a population of COVID-19 patients admitted to inpatient rehabilitation from September 2021 to March 2022 during a wave of COVID-19 infection corresponding to a hospitalization surge. In addition, a follow-up at 6 months after admission to inpatient rehabilitation assessed persistent symptoms, functional improvement, and quality of life. We hypothesized that patients recovering from COVID-19 would make clinically significant functional gains during inpatient rehabilitation. Given the previously noted prevalence of post-COVID-19 condition in individuals who experienced severe disease [16], we hypothesized that the majority of our patients would exhibit features of post-COVID-19 condition. Overall, we aim to evaluate the continued suitability of rehabilitation after COVID-19 infection and characterize patient recovery trajectories during both inpatient rehabilitation and after discharge.

2. Materials and Methods

2.1. Participants

This study included patients admitted to a single inpatient rehabilitation facility (IRF) from September 2021 to March 2022 with a COVID-19 diagnosis. Patients were required to be admitted to the IRF immediately following acute hospitalization for COVID-19, with a discharge date corresponding to the most recent COVID-19 surge in New York. Exclusion criteria included re-admission to acute care from inpatient rehabilitation with no readmission to the IRF, unexpected discharge to subacute rehabilitation, age <18, and severe cognitive disabilities potentially impacting assessments or survey responses.

2.2. Demographic and Clinical Data

Patient data including age, body mass index (BMI), gender, race, admission date, length of stay, comorbidities, and Centers for Medicare Services' Inpatient Rehabilitation Facility Patient Assessment Instrument (CMS IRF-PAI) items were collected. Clinical data were extracted from the electronic medical record (EMR), including cognitive assessments (the Brief Interview of Mental Status and the Montreal Cognitive Assessment, a more comprehensive cognitive screening tool), acute care admission date, intensive care unit (ICU) admission, ventilator use, and supplemental oxygen. In addition, data were collected for the following assessments performed at admission and discharge: the 6 Minute Walk Test (6 MWT) for aerobic capacity and endurance (in feet) [24] with rating of perceived exertion (RPE) [25]; the 5 × Sit to Stand (5 × STS) to assess lower extremity strength for transfers [26], inspiratory capacity (IC) with incentive spirometry to measure respiratory capacity; and the Euro-Quality of Life 5 Dimension 5 Length (EQ-5D-5L) survey and Visual Analog Scale (EQ-VAS) to quantify patient self-assessment of health status and quality of life [27]. For the EQ-5D-5L data, the Pareto Classification of Health Change (PCHC) was used to assess patients' health states [28]. An individual's health state was "improved" if there was improvement in at least one dimension and no deterioration in any of the

other dimensions. Their health state was deemed "worse" if there was deterioration in at least one dimension with no improvement in any other dimension. "Mixed" denoted a combination of deteriorated and improved health states, and "same" indicated health states that remained unchanged across all five dimensions between measurements. Functional abilities were scored at admission and discharge using the IRF-PAI section GG. GG mobility items include rolling left to/from right, sitting to lying, lying to sitting, sitting to standing, chair/bed-to-chair transfer, toilet transfers, and car transfers. Walking items include walking ten feet, fifty feet with 2 turns, 150 feet, navigating uneven surfaces, 1 step, 4 steps, 12 steps, and picking up an object while walking. Self-care items include eating, oral hygiene, toileting hygiene, showering/bathing, upper body dressing, lower body dressing, and donning/doffing footwear. Individual items were ranked on a scale of 1–6, with 6 representing complete functional independence for the activity. Consistent with CMS practice, codes indicating that an activity was not attempted were converted to 1. Individual item scores were summed to yield total GG scores ranging from 22–132.

2.3. Six-Month Follow-Up

At 6 months, all patients received a call from a physical therapist requesting follow-up survey completion, with verbal consent documented in the survey form. The survey included reassessment of the EQ-5D-5L and EQ-VAS, mobility using a GG item subset, oxygen use, presence of post-COVID-19 condition-associated symptoms (fatigue, shortness of breath, cough, phlegm, lack of taste, lack of smell, muscular pain, joint pain, headache, confusion, difficulty concentrating, and diarrhea), therapies received, and vaccination status.

The World Health Organization (WHO, Geneva, Switzerland) criteria were used to identify patients exhibiting features of post-COVID-19 condition [29,30]. All patients met the criterion of a confirmed COVID-19 infection. Additionally, patients had to meet the following criteria: symptoms persisting beyond the acute phase or emerging 2–3 months later; symptoms present 3–4 months after recovery and lasting two months or more; and the presence of least one symptom cluster (persistent fatigue with bodily pain or mood swings, cognitive problems, or ongoing respiratory problems) [31].

2.4. Data Analysis

The statistical analysis was performed using the SPSS Statistical Analysis Software (v26.0, IBM Corporation, 2019). Descriptive statistics were used to summarize demographic variables. Continuous outcome variables were compared using the Wilcoxon signed-rank test. Post-COVID-19 condition symptom prevalence with vaccination status and prior ventilated versus non-ventilated patient outcomes were compared using the Mann Whitney U test. Variables were considered statistically significant if $p < 0.05$. Spearman's correlation was performed to determine relationships between continuous and/or ordinal variables, with significant correlations identified at the $p < 0.01$ level. Non-parametric statistics were chosen due to the non-Gaussian distribution of outcome variables based upon visual inspection, skewness, and kurtosis Z-scores exceeding the recommended normality thresholds [32]. As data were paired, and assessments were independent, incomplete pairwise data were excluded on an assessment-by-assessment basis. Clinical significance was evaluated for assessments where a minimal clinically important difference (MCID) had previously been calculated. For EQ-5D-5L data, the PCHC was used to assess patients at discharge and at the 6-month follow-up [28].

3. Results

3.1. Demographics and Inpatient Rehabilitation Therapy Received

A total of 109 patients were admitted to Sunnyview Rehabilitation Hospital's cardiac and pulmonary unit between July 2021 and March 2022 with a COVID-19 diagnosis (Figure 1).

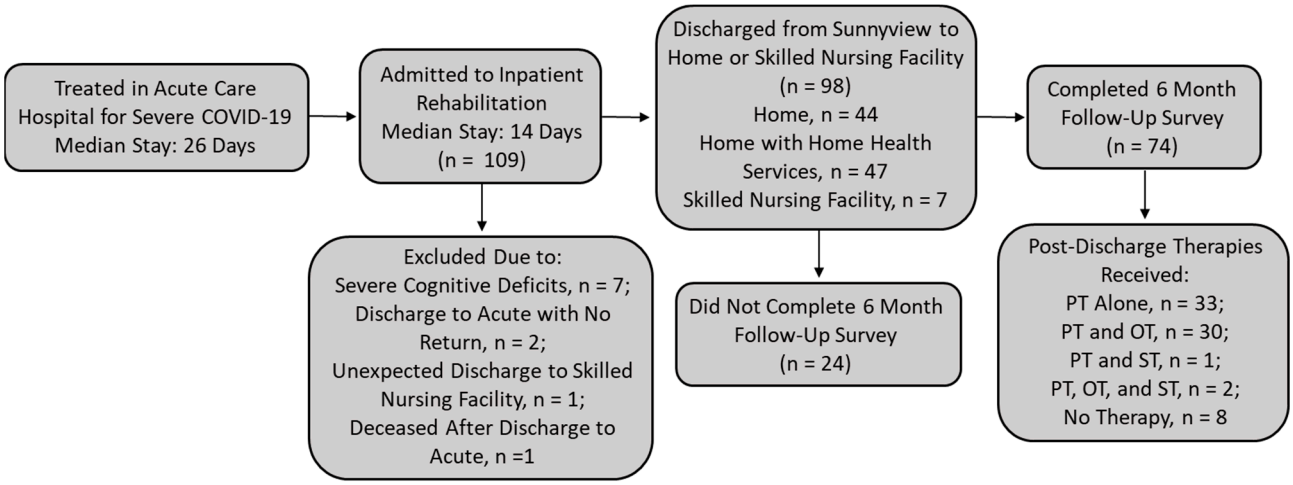

Figure 1. Scheme of patients recovering from COVID-19 admitted to inpatient rehabilitation and included in this study. PT, physical therapy; OT, occupational therapy; ST, speech therapy.

One patient passed away after discharge to acute care, two patients were discharged to acute care and did not return, and one patient was discharged unexpectedly to a skilled nursing facility (SNF). Seven patients with severe cognitive disabilities were excluded. Patients had a median age of 62, 46% were female, the median BMI was 28.0, and all patients had at least one comorbidity deemed a risk factor for severe COVID-19 (Table 1).

Table 1. Patient Characteristics [a].

Characteristic	COVID-19 Admissions, *n* = 98
Age, years [b]	62 (55.3, 73.8)
Race [c]	
White	88 (90)
African American	7 (7)
Hispanic	1 (1)
Declined	2 (2)
BMI (kg/m^2) [b]	28.0 (24.1, 32.7)
Sex (% Female) [c]	45 (46)
Comorbidities/Risk Factors [c]	
Type II Diabetes	31 (32)
Fatigue	52 (53)
COPD	18 (18)
Asthma	8 (8)
Interstitial Lung Disease	10 (10)
Pulmonary Embolism	13 (13)
Heart Failure	11 (11)
Coronary Artery Disease	12 (12)
Hypertensive Heart Disease	11 (11)
Chronic Kidney Disease	10 (10)
Obesity (BMI $\geq$ 30)	35 (36)
Acute Hospital	
Length of Stay, days [b]	26 (14, 38)
Admitted to ICU [c]	44 (45)
Ventilated [c]	37 (38)
Rehabilitation Hospital [b]	
Length of Stay, days	14 (9, 20)
Brief Interview of Mental Status (BIMS)	15 (13, 15)
Montreal Cognitive Assessment (MoCA)	24 (21, 27)

[a] Abbreviations: BMI, body mass index; ICU, intensive care unit; kg, kilogram; m, meter. [b] Data are presented as median (interquartile range); [c] data are presented as *n* (%).

Throughout their IRF stay, patients were under the care of a physician and received a medical regimen tailored to individual needs according to functional abilities, admitting diagnoses, and pre-existing comorbidities. Patients received three hours of intensive multidisciplinary therapy five days per week, with 30 min of therapy on the sixth day and a day off for rest. Depending on the needs of the patient, therapy included physical, occupational, and speech therapies, or only physical and occupational therapies if speech needs were not identified. Inpatient rehabilitation standard of care was based on the clinical judgement of the clinician, with each clinician utilizing a rehabilitation approach individualized to each patient's unique needs. Rehabilitation included therapeutic activity addressing functional deficits, therapeutic exercise addressing strength and flexibility, and neuromuscular re-education addressing balance. Along with medications addressing ongoing conditions, patients received pain medication as needed, the most common of which were acetaminophen and topical lidocaine anesthetic. This population additionally received cardiopulmonary education throughout their stay, with topics including breathing techniques, oxygen management and titration, energy conservation strategies, and healthy lifestyle changes.

3.2. Inpatient Rehabilitation Outcomes

At admission and discharge, data were collected using assessments specific to this population, including the 5 × STS, 6 MWT with RPE, inspiratory capacity, EQ-5D-5L, and EQ-VAS (Table 2). A total of 75% of patients at admission and 46% at discharge were unable to complete the 5 × STS assessment. While 43 patients (46%) showed an improvement from admission to discharge, only 19 were able to complete the test at admission and discharge, with an overall median improvement from 25 to 20 s. It was therefore determined that the 5 × STS was too difficult for this population overall to provide meaningful information on their functional recovery.

Table 2. Inpatient Rehabilitation Outcomes [a].

Assessment	Median Admission	Median Discharge	Z Score	*p* Value
5× Sit to Stand (s)	25	20	N/A	N/A
Inspiratory Capacity (mL)	900	1233	−6.55	<0.00001 [c]
6 Minute Walk Test (ft)	87	383	−7.67	<0.00001 [c]
6 Minute Walk Test Rating of Perceived Exertion [b]	5 (4, 7)	4 (3, 6)	−2.69	0.007 [c]
Functional Independence [b] Section GG Self-Care and Mobility Total	61 (52, 70)	117 (102, 126)	−8.59	<0.00001 [c]
GG Self-Care	25 (21, 28)	40 (36.25, 42)	−8.55	<0.00001 [c]
GG Mobility	36 (30, 44)	77 (66, 84)	−8.55	<0.00001 [c]

[a] Abbreviations: ft, feet; mL, milliliters; s, seconds. [b] Data are presented as median (interquartile range). [c] Statistically significant ($p < 0.05$).

For inspiratory capacity, median admission-to-discharge volume increased from 900 mL to 1233 mL ($p < 0.00001$, $n = 91$) and represented a clinically significant change when compared to an MCID of a 10% increase [33]; 62 patients (68%) exceeded the MCID. Patients (88/98) completing the 6 MWT ambulated a median distance of 87 feet in 6 min upon admission versus 383 feet upon discharge ($p < 0.00001$, $n = 88$), a median gain of 296 feet. The MCID of the 6 MWT is conservatively 177–262 feet (54–80 m) in patients with chronic pulmonary disease [34]; much lower MCID values (46–100 feet or 14.0–30.5 m) have been suggested [35]. Patients completing the 6 MWT displayed a median RPE admission-to-discharge decrease from five to four ($p = 0.007$, $n = 62$), which is modest yet clinically significant [36]. Patients' self-reported global health assessment on the EQ-VAS exhibited a median increase of 25 points (50 to 75) from admission to discharge ($p < 0.00001$, $n = 73$, Table 3).

Table 3. Supplemental Oxygen Use and Euro Quality of Life Visual Analog Scale (EQ-VAS) at Admission, Discharge, and 6 Month Follow-Up [a].

Item	Admission	Discharge	6 Month Follow-Up
Receiving Oxygen Support [b]	62 (84)	47 (64)	31 (42)
Tracheostomy Collar/Ventilator [b]	8 (11)	0	0
Oxygen Support Level, L [c]	4.5 (4)	2.4 (1.5)	0.9 (0)
EQ-VAS Score [c]	53.2 (50)	74.5 (75)	79.7 (80)

[a] Abbreviations: EQ-VAS, Euro Quality of Life Visual Analog Scale; L, liters. [b] Data are presented as *n* (%); [c] data are presented as mean (median).

The EQ-VAS MCID was determined to be eight in patients undergoing pulmonary rehabilitation, indicating a clinically significant change in our population, with a change greater than eight in fifty patients (68%) [37]. From admission to discharge, patients' functional abilities on the IRF-PAI section GG achieved median values of 61 and 117, respectively, a gain of 56 points ($p < 0.00001$, no MCID established). Patients' supplemental oxygen requirements from admission to discharge were also compared, with a significant decrease in oxygen use from 4.5 L to 2.4 L on average ($p < 0.00001$, Table 3). In addition, all eight individuals who had a tracheostomy collar or were ventilated upon admission were transitioned to nasal cannula (six) or no supplemental oxygen support (two) by discharge.

The Pareto Classification of Health Change (PCHC) was used to assess patients at discharge and 6-month follow-up, considering all five EQ-5D-5L health states (Table 4). Of the seventy-one patients who were administered the EQ-5D-5L at admission, discharge, and follow-up, forty-seven (66%) exhibited an improved health state, twenty (28%) displayed mixed changes, two (3%) were the same, and two (3%) exhibited a worse health state from admission to discharge.

Table 4. EQ-5D-5L Assessment at Admission, Discharge, and 6-Month Follow-Up Using the PCHC Method [a].

EQ-5D-5L Assessment Outcome	Mobility	Self-Care	Usual Activity	Pain/ Discomfort	Anxiety/ Depression
Admission to Discharge:					
Improved	46 (65)	43 (61)	52 (73)	28 (39)	31 (44)
Same	20 (28)	25 (35)	13 (18)	29 (41)	34 (48)
Worse	5 (7)	3 (4)	6 (8)	14 (20)	6 (8)
Discharge to 6 Month Follow-Up:					
Improved	32 (45)	26 (37)	24 (34)	16 (23)	16 (23)
Same	28 (39)	35 (49)	22 (31)	34 (48)	46 (65)
Worse	11 (15)	10 (14)	25 (35)	21 (30)	9 (13)

[a] Data are presented as *n* (%).

To evaluate the impact of prior ventilation on rehabilitation outcomes, the patients ventilated during their acute care stay ($n = 43$) were compared to their non-ventilated counterparts ($n = 55$). Previously ventilated patients were admitted to inpatient rehabilitation with less functional independence on admission, as measured by their total GG scores (Supplementary Table S1, $p < 0.001$). However, they made greater gains during inpatient rehabilitation, and discharge GG scores did not differ from the non-ventilated group ($p = 0.229$). Patients requiring ventilation ambulated a shorter distance during the 6 MWT on admission (55 vs. 110 feet, $p = 0.008$) and a greater distance upon discharge (525 vs. 297 feet, $p = 0.004$). They did not differ in the amount of supplemental oxygen needed, inspiratory capacity, or on the EQ-VAS global health self-assessment at admission and discharge.

3.3. Six-Month Follow-Up

At the six-month follow-up, one additional individual was deceased, six declined, and seventeen were unable to be reached. Seventy-four individuals in total completed the survey (Tables 3–6), representing an overall completion rate of 76%. At the 6-month follow-up, the EQ-5D-5L and EQ-VAS were administered and compared to discharge values (Table 4). Of the 71 total patients administered the EQ-5D-5L at discharge and follow-up, a smaller percentage displayed an improved health state (35%) than from admission to discharge (66%), and a greater proportion of patients showed mixed changes to their health state (51% versus 28%). A total of 7% of patients were the same and 7% were worse from discharge to follow-up. For the EQ-VAS, the median value was slightly higher than at discharge (80 vs. 75), which showed modest statistical significance ($p = 0.033$, $n = 73$) but did not surpass the MCID of 8 for clinical significance.

Table 5. GG Mobility Item Subset at Admission, Discharge, and 6-Month Follow-Up.

Assessment	Median	Maximum Achieved [a]	Z Score	*p* Value
GG Mobility Item Subset—Admission	16	0 (0)	N/A	N/A
GG Mobility Item Subset—Discharge	34	14 (19)	N/A	N/A
GG Mobility Item Subset—6-Month Follow-Up	42	57 (77)	N/A	N/A
Admission to Discharge Gain	19.5	N/A	−7.47	<0.00001 [b]
Discharge to 6-Month Follow-Up Gain	5.5	N/A	−6.29	<0.00001 [b]

[a] Data are presented as *n* (%). [b] Statistically significant ($p < 0.05$).

Table 6. Follow-Up Survey Results—Post-COVID-19 Condition-Associated Symptoms [a].

Symptom	Prior Unvaccinated Symptom Present, N (%)	Prior Vaccinated Symptom Present, N (%)
Respiratory		
Shortness of Breath	41 (80.4)	16 (69.6)
Cough	28 (54.9)	9 (39.1)
Phlegm	19 (37.3)	6 (26.1)
Neurological		
Headache	17 (33.3)	3 (13.0)
Difficulty Concentrating	20 (39.2)	6 (26.1)
Lack of Taste	13 (25.5)	1 (4.3)
Lack of Smell	13 (25.5)	3 (13.0)
Confusion	10 (19.6)	5 (21.7)
Other		
Physical Fatigue	41 (80.4)	16 (69.6)
Muscular Pain	27 (52.9)	7 (30.4)
Joint Pain	26 (51.0)	5 (21.7)
Diarrhea	8 (15.7)	2 (8.7)

[a] Data are presented as *n* (%).

A subset of seven GG mobility and walking items were assessed at the six-month follow-up; the admission-to-discharge change was compared to discharge versus follow-up (Table 5).

Items assessed included lying to sitting, sitting to lying, sitting to standing, walking ten feet, walking fifty feet with two turns, climbing four stairs, and climbing twelve stairs. The total possible score was 42 (6 per item). On admission, the median score was 16, increasing to 34 at discharge. From discharge to follow-up, the median increased to the maximum (42). On admission, no individuals achieved the maximum score, increasing to 14 (19%) at discharge and 57 (77%) at follow-up. Gains on these seven items from admission to discharge and discharge to 6 months were statistically significant ($p < 0.00001$

for both). At the 6 month follow-up, most patients (58%) did not require supplemental oxygen support, representing an increase from discharge where only 36% of patients did not require supplemental oxygen (Table 3). In addition, the average oxygen support decreased from discharge to the 6-month follow-up (2.4 to 0.9 L/min).

Patients were also asked about follow-up therapy received post-discharge from inpatient rehabilitation. A total of thirty-three patients received physical therapy alone, thirty received both physical and occupational therapies, one patient received physical and speech therapies, two patients received physical, occupational, and speech therapies, and eight patients received no therapy. For patients receiving therapy services, 52% received services through homecare, 41% received outpatient treatment, and 8% received a mix of outpatient treatment and homecare. The median number of therapy sessions per week was two (range: one to five) and the median duration was six weeks (range: one to twenty-four).

Patients were asked which of the following post-COVID-19 condition symptoms applied to them in yes/no format: fatigue, shortness of breath, cough, phlegm, lack of taste, lack of smell, muscular pain, joint pain, headache, confusion, difficulty concentrating, and diarrhea. The prevalence of individual post-COVID-19 condition-associated symptoms is included in Table 6. For identification of potential post-COVID-19 condition, WHO criteria were utilized (see Materials and Methods). Across all patients, 64 (86%) exhibited features of post-COVID-19 condition, of which 29 (45%) were female.

When asked about vaccination status prior to admission, 23 (31%) individuals indicated that they were vaccinated and 51 (69%) indicated they were unvaccinated. At the time of survey administration, an additional 18 individuals indicated that they were vaccinated, representing a vaccination rate of 35% for previously unvaccinated individuals. The overall vaccination rate 6 months after admission to inpatient rehabilitation was 55%. Individuals vaccinated prior to their illness exhibited fewer post-COVID-19 condition symptoms on average than their unvaccinated counterparts (3.4 and 5.2, respectively, $p = 0.014$, Table 6).

Spearman's rank-order correlations were conducted to examine relationships between acute and inpatient rehabilitation lengths of stay, length of ventilation, cognitive status (BIMS and MoCA), and functional outcomes at 6 months (Supplementary Table S2). Moderate, significant positive correlations were observed between days on ventilator and both acute LOS ($\rho = 0.525$) and inpatient rehabilitation LOS ($\rho = 0.490$). In addition, moderate, significant correlations were observed between the number of post-COVID-19 condition symptoms at 6 months and both the level of oxygen use ($\rho = 0.531$) and the EQ-VAS at 6 months ($\rho = -0.440$). Weaker correlations were observed between acute LOS and MoCA scores ($\rho = 0.308$); acute LOS and inpatient rehabilitation LOS ($\rho = 0.389$); MoCA and BIMS scores ($\rho = 0.394$); EQ-VAS and oxygen use ($\rho = -0.306$); EQ-VAS and GG mobility ($\rho = 0.321$); and number of post-COVID-19 condition symptoms and GG mobility ($\rho = -0.309$).

4. Discussion

The aim of this study was to describe characteristics and establish collective functional recovery trajectories of post-COVID-19 patients requiring inpatient rehabilitation from September 2021 to March 2022. This population corresponds to the third and most recent COVID-19 wave and hospitalization surge in New York State. As treatments stabilized and vaccine availability increased prior to this wave, this patient population may be more representative of future patients than previous waves. All patients displayed at least one comorbidity identified as a risk factor for severe disease [4–6]. The characteristics of their acute stay indicate the severity of their disease, with a median acute care stay of 26 days, with 45% admitted to the ICU, and 38% ventilated. A recent study identified hospitalization as the most important risk factor for post-COVID-19 condition sequelae, reporting that 79% of hospitalized patients developed post-COVID-19 condition [16]. This is consistent with our finding that 86% of our patients indicated self-reported post-COVID-19 condition symptoms.

Clinically significant changes were achieved during inpatient rehabilitation in several assessments from admission to discharge, including the 6 MWT with RPE, inspiratory capacity, and EQ-VAS. Increased inspiratory capacity indicates more effective ventilation and is associated with reduced mortality [32]. Patients exhibited improvements in both distances walked and RPE during the 6 MWT, exceeding the MCID for the 6 MWT. The change of 1 unit on the RPE indicates a modest but clinically meaningful improvement in perceived exertion during the 6 MWT and is potentially conservative due to the overall decrease in oxygen supplementation from admission to discharge. For the EQ-VAS, patients rated their own global health as improved from admission to discharge by 25 points overall, indicating a clinically significant change. This QoL improvement was durable to the 6 month follow-up, suggesting that their assessment at discharge was indicative of their longer-term self-assessed global health. Improvement on the EQ-5D-5L was greater from admission to discharge (median LOS 14 days) than from discharge to the 6 month follow-up, particularly in the mobility, self-care, and usual activity categories (Table 4), potentially due to the focus on functional independence and ADLs, as well as the post-discharge continuation of PT, OT, and/or speech therapy for most patients. Addressing pain and discomfort, as well as anxiety and depression, are areas for exploration in the comprehensive care of post-COVID-19 patients. In addition, patients' use of supplemental oxygen improved from admission to discharge, with more modest improvement from discharge to the 6 month follow-up. At the 6 month follow-up, the majority of patients demonstrated overall independence in functional mobility. Post-COVID-19 symptom prevalence at 6 months was moderately associated with a reduced overall self-assessment of global health and increased oxygen use, highlighting the potential multifactorial long-term impact of severe COVID-19 on a patient's functional recovery and quality of life.

Both previously ventilated and non-ventilated patients made significant gains during inpatient rehabilitation, with similar functional abilities on discharge. Patients ventilated in acute care were admitted with lower functional independence at admission but made greater gains from admission to discharge on both section GG of the IRF-PAI and on the 6 MWT. Ventilated patients surpassed non-ventilated patients in the median distance walked on the 6 MWT by a factor of 1.77; in addition, they displayed similar inspiratory capacity, supplemental oxygen use, and global health self-assessment on admission and discharge. Collectively, these observations are potentially partially explained by the ages of the two populations. Ventilated patients were, overall, much younger than their non-ventilated counterparts, with a median age of 55 versus 68, allowing them to regain a higher level of functional independence more quickly, with respiratory capacities reflecting those of a younger cohort.

The combination of improvements in objective and subjective outcomes underscores the ability of inpatient rehabilitation to address the needs of COVID-19 patients. Despite a much shorter time frame from admission to discharge (2 weeks on average) versus discharge to 6 month follow-up, the improvements were greater, indicating that inpatient rehabilitation promotes significant early functional gains in this population, potentially setting the trajectory for further modest yet continued improvement as patients transition to outpatient services.

Despite continued gains, 86% of individuals exhibited features of post-COVID-19 condition at the 6 month follow-up. Symptoms with the greatest self-reported prevalence included fatigue and shortness of breath, similar to previous studies investigating post-COVID-19 condition symptoms [14,21,38]. Most patients (69%) admitted to inpatient rehabilitation were unvaccinated prior to illness, and 45% remained unvaccinated at the follow-up. The interdisciplinary team played an important role in efforts to vaccinate individuals to prevent COVID-19 recurrence; vaccinations were offered and encouraged during patients' hospitalizations. An exploration of further vaccination efforts both during and beyond inpatient rehabilitation is warranted. A significantly greater number of post-COVID-19 condition symptoms were present in unvaccinated individuals, indicating the potential protective effect of vaccination even in individuals with severe disease. More

research is needed to understand the clinical course and post-hospitalization outcomes of severe COVID-19 infection in vaccinated versus unvaccinated individuals.

There is minimal literature describing the characteristics of COVID-19 patients admitted to inpatient rehabilitation following acute hospitalization, as well as their functional recovery and quality of life several months after discharge. This study quantifies improvements during inpatient rehabilitation and provides evidence supporting the continued suitability of an IRF as a discharge destination for COVID-19 patients post-hospitalization for severe disease, including the most severe cases that were ventilated during their acute hospitalization. In addition, it supports continued outpatient rehabilitation to address functional deficits associated with post-COVID-19 condition. This population would benefit from further exploration of the relationship between post-COVID-19 symptoms, functional independence, and quality of life, as well as continued follow-up to determine whether patients recovering from severe disease fully return to their previous state of health.

Limitations

This study included patients at a single IRF during a single wave of COVID-19 infection; thus, it may not represent the diversity of the overall population. COVID-19 patients were not compared to matched controls, limiting the analysis of the specific impact of inpatient rehabilitation on outcomes within this population. Not all patients completed the follow-up, further limiting the population studied. The 6-month follow-up survey was conducted by telephone with no in-person assessment; therefore, the results were not based on objective clinical observations and may be biased by patient recall. Finally, additional COVID-19 variants and improved treatments could further alter the characteristics of the population requiring inpatient rehabilitation following acute hospitalization, limiting the applicability of these results to future patients.

5. Conclusions

This study underscores the importance of inpatient rehabilitation for the post-COVID-19 population, and highlights continued post-acute care needs several months beyond discharge. With a focus on patients in a later wave of COVID-19, we observed clinically meaningful improvements in outcomes, justifying the continued suitability and appropriateness of inpatient rehabilitation for post-COVID-19 patients, including the most severe cases that required ventilation during their acute hospitalization. Continued long term follow-up of patients with post-COVID-19 condition is warranted to further assess symptom prevalence, progression over time, and vaccination impact on severity.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/covid3090091/s1, Table S1: Inpatient Rehabilitation Outcomes of Non-Ventilated Versus Ventilated Patients; Table S2: Spearman's Rank-Order Correlations Between Lengths of Stay, Days on Ventilator, Cognitive Status, and Outcomes at 6 Month Follow-Up Spearman's ρ values are shown.

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Informed Consent Statement: Patient consent for the retrospective data review portion of this study was waived due to the retrospective nature and minimal risk of the study. For the follow-up survey, verbal consent was obtained and documented in the survey form.

Data Availability Statement: The data presented in this study are available on request from the corresponding author and with the permission of Trinity Health New York. The data are not publicly available as they contain information that could compromise the privacy of research participants.

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References

1. COVID Data Tracker. Centers for Disease Control and Prevention. Available online: https://covid.cdc.gov/covid-data-tracker/ (accessed on 13 March 2023).
2. Wu, Z.; McGoogan, J.M. Characteristics of and Important Lessons from the Coronavirus Disease 2019 (COVID-19) Outbreak in China: Summary of a Report of 72,314 Cases from the Chinese Center for Disease Control and Prevention. *JAMA* **2020**, *323*, 1239–1242. [CrossRef]
3. Serafim, R.B.; Povoa, P.; Souza-Dantas, V.; Kalil, A.C.; Salluh, J.I.F. Clinical Course and outcomes of critically ill patients with COVID-19 infection: A systematic review. *Clin. Microbiol. Infect.* **2021**, *27*, 47–54. [CrossRef] [PubMed]
4. Alahmari, A.K.; Almalki, Z.S.; Albassam, A.A.; Alsultan, M.M.; Alshehri, A.M.; Ahmed, N.J.; Alqahtani, A.M. Factors Associated with Length of Hospital Stay among COVID-19 Patients in Saudi Arabia: A Retrospective Study during the First Pandemic Wave. *Healthcare* **2022**, *10*, 1201. [CrossRef] [PubMed]
5. Bociąga-Jasik, M.; Wojciechowska, W.; Terlecki, M.; Wizner, B.; Rajzer, M.; Garlicki, A.; Sładek, K.; Krzanowska, K.; Wordliczek, J.; Krzanowski, M.; et al. Comparison between COVID-19 outcomes in the first 3 waves of the pandemic: A reference hospital report. *Pol. Arch. Intern. Med.* **2022**, *132*, 16286. [CrossRef] [PubMed]
6. Liu, W.; Yang, C.; Liao, Y.G.; Wan, F.; Lin, L.; Huang, X.; Zhang, B.H.; Yuan, Y.; Zhang, P.; Zhang, X.J.; et al. Risk factors for COVID-19 progression and mortality in hospitalized patients without pre-existing comorbidities. *J. Infect. Public Health* **2022**, *15*, 13–20. [CrossRef]
7. Abramoff, B.A.; Dillingham, T.R.; Caldera, F.E.; Ritchie, M.D.; Pezzin, L.E. Inpatient Rehabilitation Outcomes after Severe COVID-19 Infections: A Retrospective Cohort Study. *Am. J. Phys. Med. Rehabil.* **2021**, *100*, 1109–1114. [CrossRef]
8. Jain, E.; Harmon, E.Y.; Sonagere, M.B. Functional outcomes and post-discharge care sought by patients with COVID-19 compared to matched controls after completing inpatient acute rehabilitation. *PMR* **2021**, *13*, 618–625. [CrossRef]
9. Olezene, C.S.; Hansen, E.; Steere, H.K.; Giacino, J.T.; Polich, G.R.; Borg-Stein, J.; Zafonte, R.D.; Schneider, J.C. Functional outcomes in the inpatient rehabilitation setting following severe COVID-19 infection. *PLoS ONE* **2021**, *16*, e0248824. [CrossRef]
10. Puchner, B.; Sahanic, S.; Kirchmair, R.; Pizzini, A.; Loffler-Ragg, J. Beneficial effects of multi-disciplinary rehabilitation in postacute COVID-19: An observational cohort study. *Eur. J. PMR Med.* **2021**, *57*, 189–198. [CrossRef]
11. Rahmati, M.; Molanouri Shamsi, M.; Woo, W.; Koyanagi, A.; Won Lee, S.; Keon Yon, D.; Shin, J.I.; Smith, L. Effects of physical rehabilitation interventions in COVID-19 patients following discharge from hospital: A systematic review. *J. Integr. Med.* **2023**, *21*, 149–158. [CrossRef]
12. Halpin, S.J.; McIvor, C.; Whyatt, G.; Adams, A.; Harvey, O.; McLean, L.; Walshaw, C.; Kemp, S.; Corrado, J.; Singh, R.; et al. Postdischarge symptoms and rehabilitation needs in survivors of COVID-19 infection: A cross-sectional evaluation. *J. Med. Virol.* **2021**, *93*, 1013–1022. [CrossRef]
13. Amato-Curran, S.; Green, K.; Rader, T.; Shimek, A. COVID-19: The Effects on the Course, Outcomes, and Discharge Destination from Acute Rehabilitation. *Rehabil. Nurs.* **2022**, *47*, 84–91. [CrossRef]
14. Carfi, A.; Bernabei, R.; Landi, F. Persistent Symptoms in Patients after Acute COVID-19. *JAMA* **2020**, *324*, 603–605. [CrossRef]
15. Curci, C.; Negrini, F.; Ferrillo, M.; Bergonzi, R.; De Sire, A. Functional outcome after inpatient rehabilitation in post-intensive care unit COVID-19 patients: Findings and clinical implications from a real-practice retrospective study. *Eur. J. Phys. Rehabil. Med.* **2021**, *57*, 443–450. [CrossRef] [PubMed]
16. Ahmad, I.; Edin, A.; Granvik, C.; Kumm Persson, L.; Tevell, S.; Månsson, E.; Magnuson, A.; Marklund, I.; Persson, I.L.; Kauppi, A.; et al. High prevalence of persistent symptoms and reduced health-related quality of life 6 months after COVID-19. *Front. Public Health* **2023**, *11*, 1104267. [CrossRef]
17. Jennings, G.; Monaghan, A.; Xue, F.; Duggan, E.; Romero-Ortuño, R. Comprehensive Clinical Characterisation of Brain Fog in Adults Reporting Post-COVID-19 Condition Symptoms. *J. Clin. Med.* **2022**, *11*, 3440. [CrossRef]
18. Journeay, W.S.; Robinson, L.R.; Titman, R.; Macdonald, S.L. Characteristics and outcomes of COVID-19-Positive Individuals Admitted for Inpatient Rehabilitation in Toronto, Canada. *J. Rehabil. Med. Clin. Commun.* **2021**, *4*, 1000053. [CrossRef] [PubMed]
19. Premraj, L.; Kannapadi, N.V.; Briggs, J.; Seal, S.M.; Battaglini, D.; Fanning, J.; Suen, J.; Robba, C.; Fraser, J.; Cho, S.M. Mid and long-term neurological and neuropsychiatric manifestations of post-COVID-19 syndrome: A meta-analysis. *J. Neurol. Sci.* **2022**, *434*, 120162. [CrossRef]
20. Nasserie, T.; Hittle, M.; Goodman, S.N. Assessment of the Frequency and Variety of Persistent Symptoms among Patients with COVID-19: A Systematic Review. *JAMA* **2021**, *4*, e2111417. [CrossRef]

21. Logue, J.K.; Franko, N.M.; McCulloch, D.J.; McDonald, D.; Magedson, A.; Wolf, C.R.; Chu, H.Y. Sequelae in Adults at 6 Months After COVID-19 Infection. *JAMA Netw. Open* **2021**, *4*, e210830. [CrossRef] [PubMed]
22. Gabunia, S.; Harmon, E.Y.; Sonagere, M.B.; Teale, A.E. Characteristics and Outcomes of COVID-19 Survivors Requiring Inpatient Rehabilitation: A Comparison of Two Waves. *Am. J. Phys. Med. Rehabil.* **2023**, *102*, 206–213. [CrossRef] [PubMed]
23. Viñas, P.; Martín-Martínez, A.; Alarcón, C.; Riera, S.A.; Miró, J.; Amadó, C.; Clavé, P.; Ortega, O. A Comparative Study between the Three Waves of the Pandemic on the Prevalence of Oropharyngeal Dysphagia and Malnutrition among Hospitalized Patients with COVID-19. *Nutrients* **2022**, *14*, 3826. [CrossRef] [PubMed]
24. Matos Casano, H.A.; Anjum, F. Six Minute Walk Test. In *StatPearls*; StatPearls Publishing: Treasure Island, FL, USA, 2022. Available online: https://www.ncbi.nlm.nih.gov/books/NBK576420/ (accessed on 13 December 2022).
25. Borg, G.A. Psychophysical bases of perceived exertion. *Med. Sci. Sports Exerc.* **1982**, *14*, 377–381. [CrossRef]
26. Guralnik, J.M.; Simonsick, E.M.; Ferrucci, L.; Glynn, R.J.; Berkman, L.F.; Blazer, D.G.; Scherr, P.A.; Wallace, R.B. A short physical performance battery assessing lower extremity function: Association with self-reported disability and prediction of mortality and nursing home admission. *J. Gerontol.* **1994**, *49*, M85–M94. [CrossRef] [PubMed]
27. Herdman, M.; Gudex, C.; Lloyd, A.; Janssen, M.; Kind, P.; Parkin, D.; Bonsel, G.; Badia, X. Development and preliminary testing of the new five-level version of EQ-5D (EQ-5D-5L). *Qual. Life Res.* **2011**, *20*, 1727–1736. [CrossRef]
28. Devlin, N.; Parkin, D.; Janssen, B. *Methods for Analysing and Reporting EQ-5D Data*; Springer International Publishing: Cham, Switzerland, 2020. [CrossRef]
29. Soriano, J.B.; Murthy, S.; Marshall, J.C.; Relan, P.; Diaz, J.V. WHO Clinical Case Definition Working Group on Post-COVID-19 Condition. A clinical case definition of post-COVID-19 condition by a Delphi consensus. *Lancet Infect. Dis.* **2022**, *22*, e102–e107. [CrossRef]
30. Maes, M.; Al-Rubaye, H.T.; Almulla, A.F.; Hadrawi, D.S.; Stoyanova, K.; Kubera, M.; Al-Hakeim, H.K. Lowered Quality of Life in Long COVID Is Predicted by Affective Symptoms, Chronic Fatigue Syndrome, Inflammation and Neuroimmunotoxic Pathways. *Int. J. Environ. Res. Public Health* **2022**, *19*, 10362. [CrossRef]
31. Global Burden of Disease Long COVID Collaborators. Estimated Global Proportions of Individuals with Persistent Fatigue, Cognitive, and Respiratory Symptom Clusters Following Symptomatic COVID-19 in 2020 and 2021. *JAMA* **2022**, *328*, 1604–1615. [CrossRef]
32. Kim, H.Y. Statistical notes for clinical researchers: Assessing normal distribution (2) using skewness and kurtosis. *Restor. Dent. Endod.* **2013**, *38*, 52–54. [CrossRef]
33. Behr, J. A small change in FVC but a big change for IPF: Defining the minimal clinically important difference. *Am. J. Respir. Crit. Care Med.* **2011**, *184*, 1329–1330. [CrossRef]
34. Wise, R.A.; Brown, C.D. Minimal clinically important differences in the six-minute walk test and the incremental shuttle walking test. *COPD* **2005**, *2*, 125–129. [CrossRef] [PubMed]
35. Bohannon, R.W.; Crouch, R. Minimal clinically important difference for change in 6-minute walk test distance of adults with pathology: A systematic review. *J. Eval. Clin. Pract.* **2017**, *23*, 377–381. [CrossRef] [PubMed]
36. Ries, A.L. Minimally clinically important difference for the UCSD Shortness of Breath Questionnaire, Borg Scale, and Visual Analog Scale. *COPD* **2005**, *2*, 105–110. [CrossRef]
37. Zanini, A.; Aiello, M.; Adamo, D.; Casale, S.; Cherubino, F.; Della Patrona, S.; Raimondi, E.; Zampogna, E.; Chetta, A.; Spanevello, A. Estimation of minimal clinically important difference in EQ-5D visual analog scale score after pulmonary rehabilitation in subjects with COPD. *Respir. Care* **2015**, *60*, 88–95. [CrossRef] [PubMed]
38. Nalbandian, A.; Sehgal, K.; Gupta, A.; Madhavan, M.V.; McGroder, C.; Stevens, J.S.; Cook, J.R.; Nordvig, A.S.; Shalev, D.; Sehrawat, T.S.; et al. Post-acute COVID-19 syndrome. *Nat. Med.* **2021**, *27*, 601–615. [CrossRef]

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